ILEE-QuakeCoRE Proposed Shake-Table Test of a Low-Damage Concrete Wall Building

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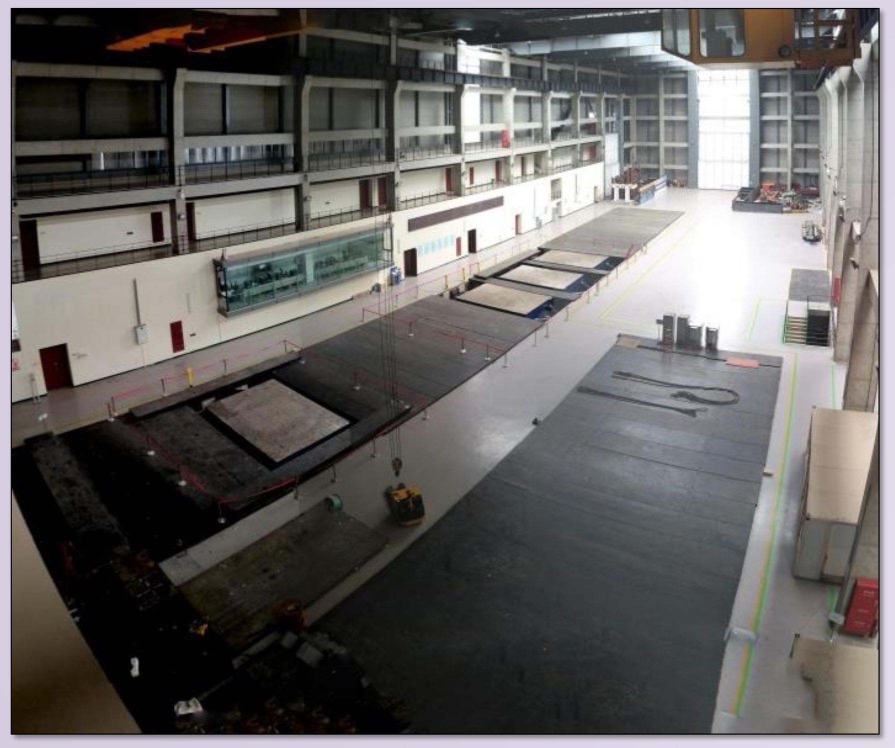
Introduction

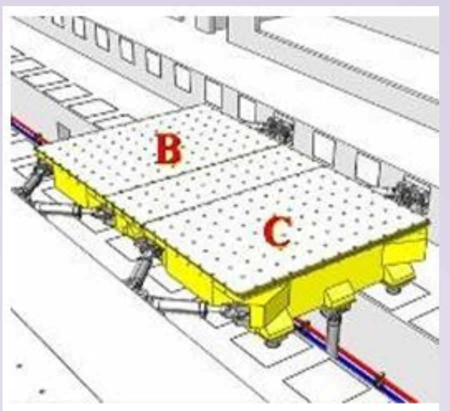
The increasing need to reduce damage and downtime of modern buildings in addition to life-safety has led to the development of the low-damage design philosophy where the earthquakes can be resisted by structures with damage confined to easily replaceable components. Existing low-damage research has typically focused on testing and modelling individual components, at reduced scales, and using simplified slow loading protocols which does not account for the complex interactions that can occur in real buildings during earthquakes. To provide essential evidence to support the development of low-damage concrete structures, a system level shake-table test of a full-scale low-damage concrete wall building will be tested in early 2018. The main objectives of the test are:

- Verify the seismic response of a low-damage concrete wall building implementing state-of-art design concepts.
- Verify practical construction details that are likely to be used in low-damage buildings.
- Investigate the effects of interactions between structural components.

ILEE Shake Table

The shake table test is a joint research project between the NZ Centre for Earthquake Resilience (QuakeCoRE) and the International Joint Research Laboratory of Earthquake Engineering (ILEE). It will be tested on the ILEE multi-functional shake-table array at Tongji University, China, as shown in Figure 1.





DOF	2 horizontal DOF
Dimension	10 x 6 m
Displacement	500 mm both directions
Velocity	1000 mm/s both directions
Acceleration	1.5g both directions
Payload	140 t
Frequency	0.1-50 Hz
OTM	800 t-m at both directions

Figure 1 ILEE Shake Table Array

Preliminary Design

Building Description

The overview of the test building is shown in Figure 2. The test building is a two-storey building with plan dimensions of 5.4 x 8.95 m. The total height of the building is 8 m with each storey 4 m. The building consists of:

- Two exterior post-tensioned (PT) walls in each direction to resist lateral loads.
- One perimeter frame to carry gravity loads.
- Level 1: Long-span precast concrete double tees with insitu concrete topping.
- Level 2: Composite floor with ComFlor steel decking as permanent formwork and concrete topping.

Building weight is shown in Table 1 and member size is shown in Table 2.

Table 1 Building weight

Level	Weight (t)
Level 2	35.3
Level 1	43.9
Foundation	41.2
Total	120.4

Table 2 Member size

Member	Size (mm)
Columns at all levels	400 x 400
Beams at all levels	300 x 400
Walls at longitudinal	150 x 2500
Walls at transverse	150 x 2000
Double-Tee floor	300TT
Composite floor	ComFlor 60 130

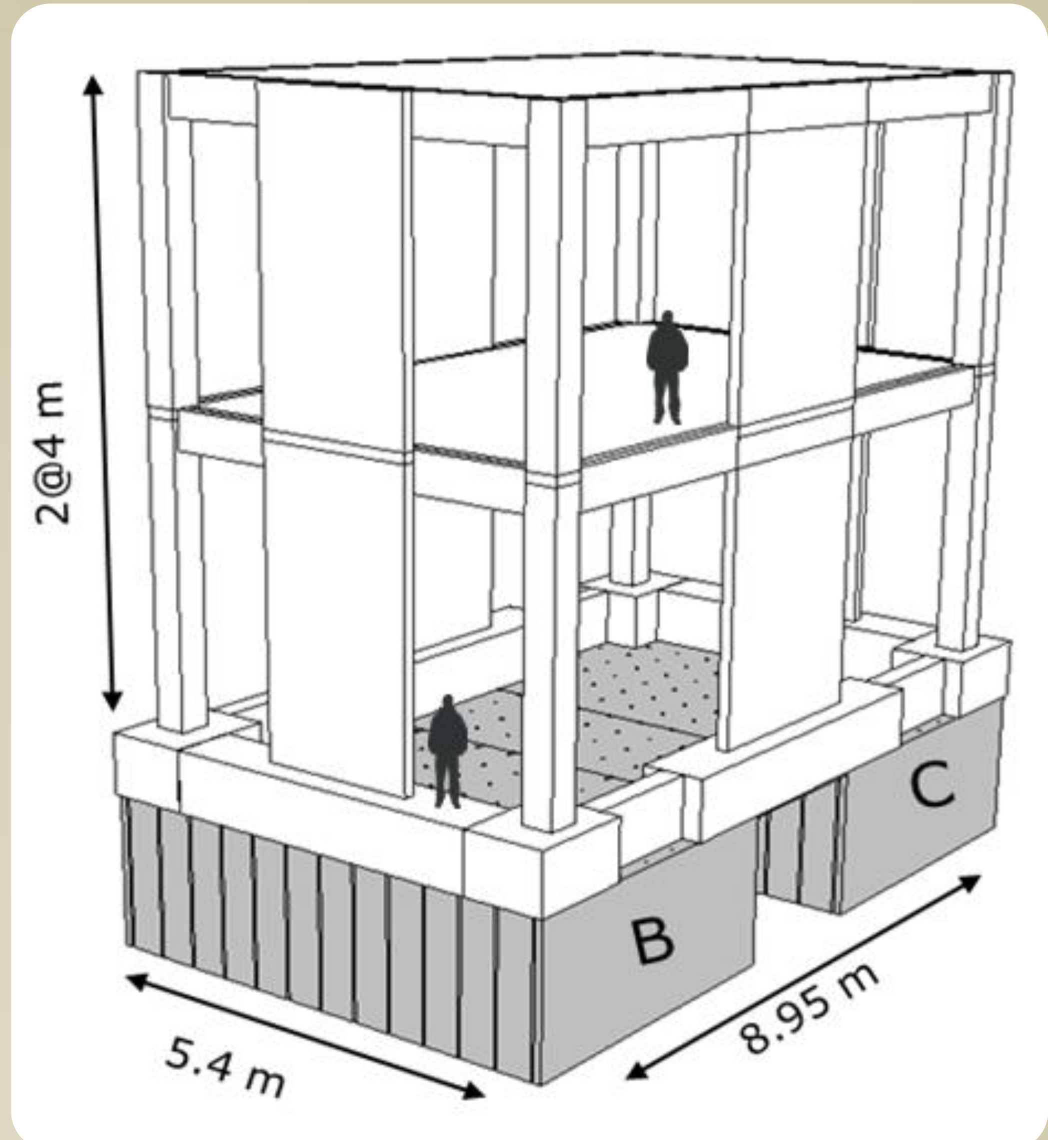


Figure 2 Overview of test building

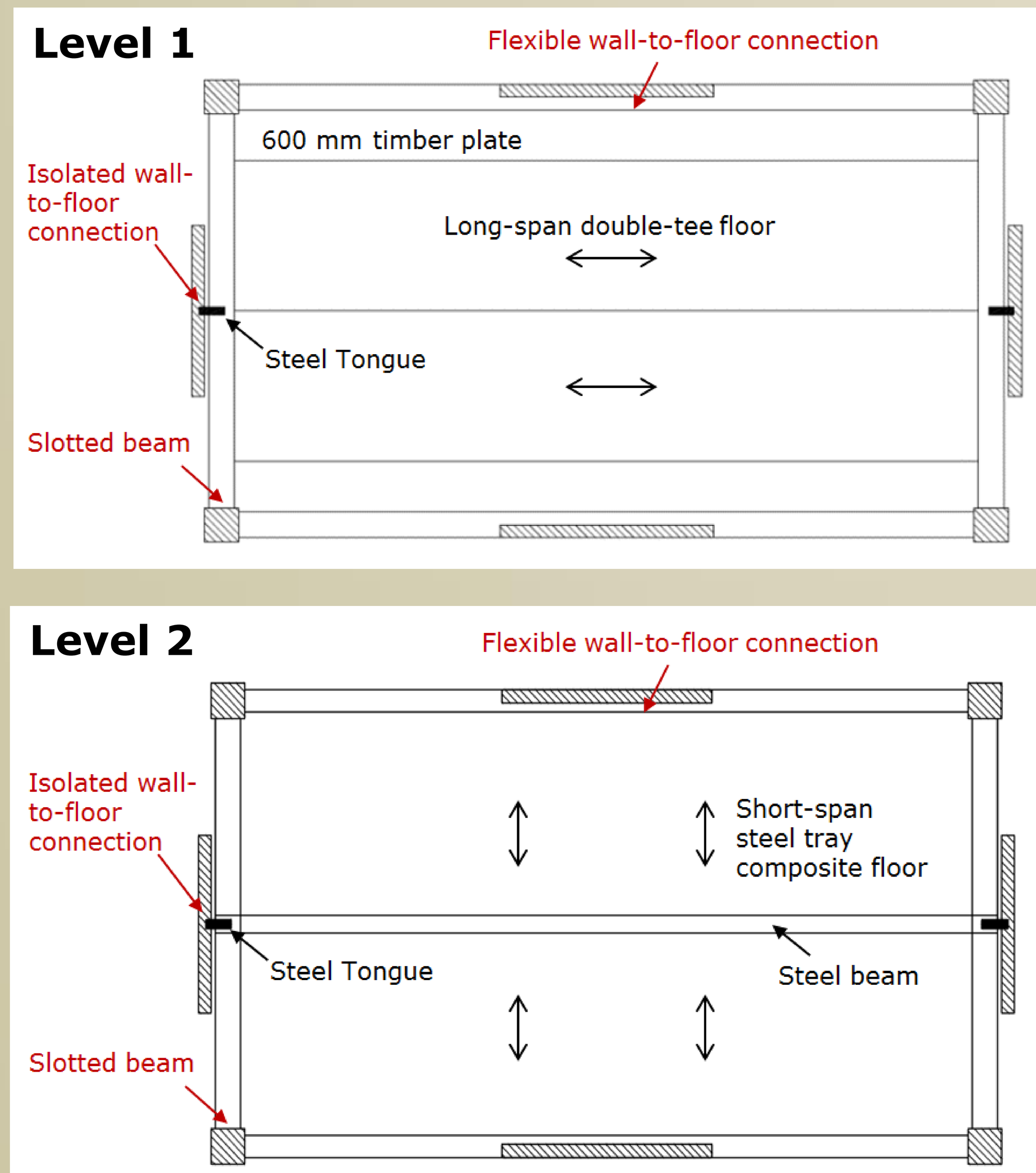
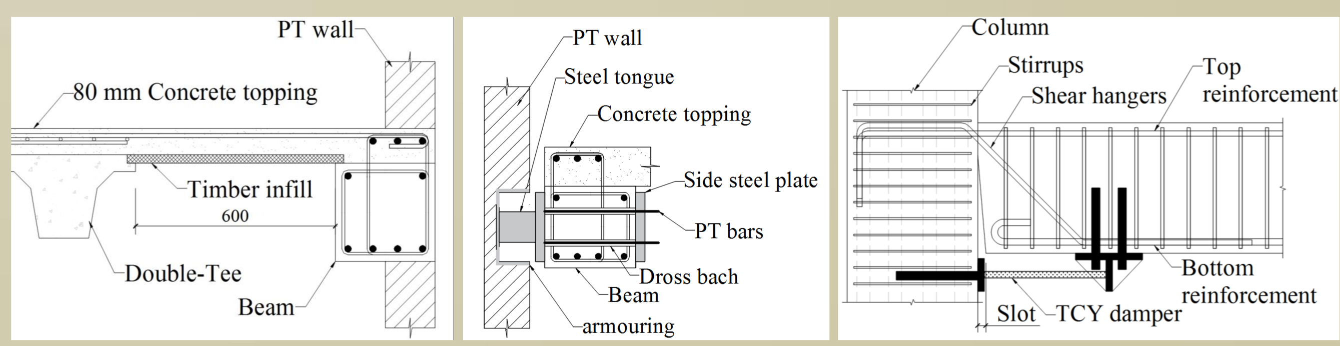


Figure 3 Building plans for level 1 and 2

Connection Design

- Flexible wall-to-floor connections will be used in the longitudinal direction. These connections are stiff in-plane to transfer diaphragm actions, but flexible out-of-plane to accommodate the uplift of the PT walls.
- Isolated wall-to-floor connections will be used in the transverse direction. The lateral forces can be transferred to the walls through a steel tongue in bearing, while the steel tongue is free to slide/move vertically to accommodate the uplift of the PT walls.
- Slotted beam connections will be used to eliminate axial elongation that may damage the floor. The connections will either be pin jointed, or include energy dissipating devices at the beam-column joints.



Flexible wall-to-floor connection | Isolated wall-to-floor connection | Slotted beam connection

Figure 4 Wall-to-floor and beam-column connections

Test Variations

The building is intended to be located in Wellington, New Zealand and will be designed into three cases:

Design cases	Design drift	Target damping	Damper
Case 1	2%	5%	Only wall base
Case 2	1%	5%	Only wall base
Case 3	1%	12%	Wall base and beam-column joint

Four types of dampers will be used either at beam-column joints or PT wall base in the building , as shown in Figure 5. They are:

- Conventional steel fuses
- Viscous fluid damper
- Lead extrusion (HF2V) damper

A Combination of different dampers installed in the building will be tested, as shown in Table 3. Torsion will be induced during several tests.

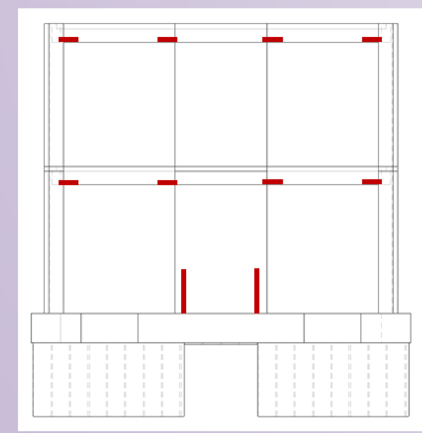


Table 3 Test Variables

Test	Beam-column joints	Wall base	Drift
1	No	Steel fuse	2%
2	No	Steel fuse	1%
3	Steel fuse	Steel fuse	1%
4	Steel fuse	Viscous damper	1%
5	HF2V	Viscous damper	1%

Modelling Competition

A blind modelling contest will be conducted for the test building. The building design will be circulated prior to the test to allow participants to construct numerical models to predict the response. Comparisons of the test and simulation will be evaluated and published.

Acknowledgements

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